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14. ABSTRACT This project examined China's drive to become a world-class defense and dual-use technological and industrial power and this transformation's implications for the United States. This resulted in the development of new analytical frameworks for analyzing defense innovation, especially with understanding how latecomer countries engage in technological catching up, better defining what is meant by innovation, and forging inter-disciplinary approaches to research between the sciences and social sciences. Outcomes have included numerous research conferences, workshops, research papers, policy briefs and publications, generated policy and media briefings, and					
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Report Title

Final Report: The Evolving Relationship Between Technology and National Security in China: Innovation, Defense Transformation, and China's Place in the Global Technology Order

ABSTRACT

This project examined China's drive to become a world-class defense and dual-use technological and industrial power and this transformation's implications for the United States. This resulted in the development of new analytical frameworks for analyzing defense innovation, especially with understanding how latecomer countries engage in technological catching up, better defining what is meant by innovation, and forging inter-disciplinary approaches to research between the sciences and social sciences. Outcomes have included numerous research conferences; workshops; research papers, policy briefs and publications generated; policy and media briefings, and pipeline training for students and junior academics. A Relational Database has been produced to support social network analysis to characterize the positions of individuals, organizations, projects and technologies within networks in China, as well as provide general characterizations of the nature of these networks. New ARO funding is secured for a three-year follow-up project on "Understanding China's Efforts to Become a Global Defense Science, Technology, and Innovation Leader." This will allow continued work in the areas of: 1) China's Defense RDA System; 2) Annual Review of China's Defense Industrial Base, and 3) Applying Lessons Learned from China to Understand How Other Countries Become Military Technological and Industrial Powers.

Enter List of papers submitted or published that acknowledge ARO support from the start of the project to the date of this printing. List the papers, including journal references, in the following categories:

(a) Papers published in peer-reviewed journals (N/A for none)

Received

Paper

08/30/2011 15.00 Bates Gill. Diffuse Threats, Frail Institutions: Managing Security in the New Era, Current History, (11 2010): 329. doi:

08/30/2011 16.00 Dieter Ernst. Upgrading through Innovation in a Small Network Economy: Insights from Taiwan's IT industry, Economics of Innovation and New Technology, (06 2010): 295. doi:

09/03/2010 1.00 T. Cheung. Dragon on the Horizon: China's Defense Industrial Renaissance, , (02 2009): . doi:

TOTAL: 3

Number of Papers published in peer-reviewed journals:

(b) Papers published in non-peer-reviewed journals (N/A for none)

<u>Received</u>	<u>Paper</u>
08/31/2011 14.00	Bates Gill. Good Nuclear Governance and Nuclear Security: Challenges, Implications, and Responses, IFANS Review (Seoul), (12 2010): 1. doi:
10/01/2014 08.00	Jordan Wilson. "Supercomputing and Energy in China: How Investment in HPC Affects Oil Security", SITC Bulletin Analysis, (01 2014): 0. doi:
10/01/2014 09.00	Kevin Pollpeter. China's Space Robotic Arm Programs, SITC Bulletin Analysis, (10 2013): 0. doi:
11/14/2013 52.00	Oliver_Brauner. Is Europe Feeding the Dragon? EU Transfers of Militarily Relevant Technologies to China, Journal of East Asian Studies, (09 2013): 0. doi:
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11/14/2013 54.00	Yoram_Evron. Between Beijing and Washington: Israel's Technology Transfers to China, Journal of East Asian Studies, (09 2013): 0. doi:
11/14/2013 55.00	Tomoo_Marukawa. Japan's High-Technology Trade with China and Its Export Control, Journal of East Asian Studies, (09 2013): 0. doi:
TOTAL:	7

Number of Papers published in non peer-reviewed journals:

(c) Presentations

Non Peer-Reviewed Conference Proceeding publications (other than abstracts):

<u>Received</u>	<u>Paper</u>
02/12/2016 80.00	Andrew_Erickson. The Roles and Influence of Chief Commanders and Chief Designers, IGCC 2014 Annual Conference on the Chinese Defense Industry: Personalities, Talent, and the Human Capital Base," UC San Diego, La Jolla, CA, August 9-10, 2014. 09-AUG-14, . : ,
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08/28/2015 59.00	Kevin_Pollpeter. Red, But More Expert: The Evolution of China's "Two Chiefs" Program Manager System, SITC Research Brief No. 4, IGCC 2014 Annual Conference on "The Chinese Defense Industry: Personalities, Talent, and the Human Capital Base," held at UC San Diego, La Jolla, CA, August 9-10, 2014. 09-AUG-14, . : ,
08/28/2015 75.00	Fan_Yang___. Surveying China S&T Human Talents Programs, IGCC 2014 Annual Conference on "The Chinese Defense Industry: Personalities, Talent, and the Human Capital Base," held at UC San Diego, La Jolla, CA, August 9-10, 2014. 09-AUG-14, . : ,
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- 08/29/2013 59.00 Stephan_Haggard. The East Asian Political Economy: Stylized Facts and Security Debates, Rich Region, Strong States: The Political Economy of Security in Asia. 05-NOV-12, . : ,
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- 08/29/2013 64.00 Kevin_Pollpeter. China's Second Ballistic Missile Defense Test: A Search for Strategic Stability, Rich Region, Strong States: The Political Economy of Security in Asia. 05-NOV-12, . : ,
- 08/29/2013 65.00 Susan_Shirk. Can China's Political System Sustain Its Peaceful Rise?, Rich Region, Strong States: The Political Economy of Security in Asia. 05-NOV-12, . : ,
- 08/29/2013 66.00 Toshi_Yoshihara. China's Political Uses of Sea Power, Rich Region, Strong States: The Political Economy of Security in Asia. 05-NOV-12, . : ,
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- 08/29/2013 76.00 Eric_Anderson, Ling_Chen, Barry_Naughton. Report on Initial Findings of UCSD-Tsinghua U.S.-China Innovation Survey of Expert Opinion,
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- 08/29/2013 77.00 Charles_Shank. Federally-Funded Research and Development Centers (FFRDCs) and Universities in the U.S.,
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- 08/29/2013 83.00 Maggie_Marcum. Research, Development, and Acquisition: A Comparative Study of Fighter Development Timelines,
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- 08/29/2013 90.00 Tai_Ming_Cheung. Standing on the Shoulders of Past Pioneers: The Role of Foreign Technology Transfers in China's Defense Research, Development, and Acquisition Process,
Conference on the Chinese Defense Industry: Understanding the Structure, Process, and Performance of the Chinese Defense Research, Development, and Acquisition System. 29-JUL-13, . : ,
- 08/29/2013 91.00 Kate_Walsh. China's Technology Acquisition Processes—Future Integrator and Supplier,
Conference on the Chinese Defense Industry: Understanding the Structure, Process, and Performance of the Chinese Defense Research, Development, and Acquisition System. 29-JUL-13, . : ,
- 08/29/2013 89.00 Daniel_Alderman, Jana_Allen, Aaron_Shraberg, Susan_Puska. Understanding the Nature of Linkages in China's Defense RDA System,
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- 08/29/2013 92.00 Kevin_Pollpeter, Patrick_Besha, Alanna_Krolikowski. The Highest Secret: Research, Development, and Acquisition in the Beidou Navigation Satellite Programs,
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- 08/29/2013 94.00 Kevin_Pollpeter, Eric_Anderson, Joe_McReynolds, LeighAnn_Ragland, Gary_Thomas. Enabling Information-Based System of System Operations: The RDA Process for the Integrated Command Platform,
Conference on the Chinese Defense Industry: Understanding the Structure, Process, and Performance of the Chinese Defense Research, Development, and Acquisition System. 29-JUL-13, . : ,

- 08/29/2013 95.00 Gabe_Collins, Morgan_Clemens, Kristen_Gunness. Naval Shipbuilding Development Topic: Type 54 Frigate,
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- 08/29/2013 96.00 Cortez_Cooper, Daniel_Alderman, Mark_Cozad. Ordnance Industry Topic: MLRS,
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The Chinese Defense Economy Takes Off: Sector-by-Sector Assessments and the Role of Military End Users. 16-JUL-12, . : ,
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- 08/31/2014 22.00 Yuan__Wang. The Historical Evolution of STI Policy Decision-making and Key System Characteristics in the United States,
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- 08/31/2014 27.00 William_B._Bonvillian. The Evolving Organization of U.S. Innovation Agencies: An Overview,
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- 08/31/2014 28.00 Mike_Holland. Key Players and the Nature of Their Interactions in U.S. STI Policy: Resource and Budgetary Allocations by White House and Congress,
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"Dialogue on Comparing U.S. and Chinese Approaches to Science, Technology, and Innovation (STI) Policy Decision-making", UC San Diego, La Jolla, California, August 1-2, 2013.. 01-AUG-13, . : ,

- 08/31/2014 30.00 Deborah_D._Stine. The Roles and Influence of Congressionally-Chartered Honorific Organizations on STI Policy Decision-making in the United States,
"Dialogue on Comparing U.S. and Chinese Approaches to Science, Technology, and Innovation (STI) Policy Decision-making", UC San Diego, La Jolla, California, August 1-2, 2013. 01-AUG-13, . : ,
- 08/31/2014 31.00 Kaye_Husbands_Fealing. Federally-funded Research and Development Centers and Universities: Roles and Influence on STI Policy Decision-Making in the United States,
"Dialogue on Comparing U.S. and Chinese Approaches to Science, Technology, and Innovation (STI) Policy Decision-making", UC San Diego, La Jolla, California, August 1-2, 201. 02-AUG-13, . : ,
- 08/31/2014 32.00 Charles_V._Shank. Federally-Funded Research and Development Cnters and Universities: Roles and Influence on STI Policy Decision-making in the United States,
"Dialogue on Comparing U.S. and Chinese Approaches to Science, Technology, and Innovation (STI) Policy Decision-making", UC San Diego, La Jolla, California, August 1-2, 2013. 02-AUG-13, . : ,
- 08/31/2014 33.00 Fuquan_Sun. The Role of Research Institutes and Universities in Science and Technology Decision-making in China,
"Dialogue on Comparing U.S. and Chinese Approaches to Science, Technology, and Innovation (STI) Policy Decision-making", UC San Diego, La Jolla, California, August 1-2, 2013.. 01-AUG-13, . : ,
- 08/31/2014 34.00 Tai Ming_Cheung. The Current State of Defense Innovation in China and Future Prospects,
"Comparing Defense Innovation in the United States, China, Russia, and India," conference held at the University of California, San Diego, August 26-27, 2013.. 26-AUG-13, . : ,

TOTAL: 79

Number of Non Peer-Reviewed Conference Proceeding publications (other than abstracts):**Peer-Reviewed Conference Proceeding publications (other than abstracts):**ReceivedPaper

- 02/12/2016 79.00 Alanna_Krolikowski. Is There a Chinese Culture of Defense Technology and Innovation?,
Conference on Historical Influence of Contemporary Chinese Grand Strategic Thinking on Science and
Technology, University of California, San Diego, La Jolla, California, October 17-18, 2013. 18-AUG-13, . :
,
- 08/24/2012 6.00 Richard A. Bitzinger. China's Defense Technology and Industrial Base in a Regional Context: Arms
Manufacturing in Asia,
Journal of Strategic Studies, Special Issue, June 2011.. 01-JUL-10, . : ,
- 08/30/2011 7.00 Dennis J. Blasko. "Technology Determines Tactics": The Relationship between Technology and Doctrine
in Chinese Military Thinking,
Journal of Strategic Studies, Special Issue, July 2011. 01-JUL-10, . : ,
- 08/30/2011 12.00 Kevin Pollpeter. Upward and Onward: Technological Innovation and Organizational Change in China's
Space Industry,
Journal of Strategic Studies, Special Issue, July 2011. 01-JUL-10, . : ,
- 08/30/2011 11.00 Alison Peet, Samm Tyroler-Cooper. The Chinese Aviation Industry: Techno-Hybrid Patterns of
Development in the C919 Program,
Journal of Strategic Studies, Special Issue, July 2011. 01-JUL-10, . : ,
- 08/30/2011 10.00 Thomas G. Mahnken. China's Anti-Access Strategy in Historical and Theoretical Perspective ,
Journal of Strategic Studies, Special Issue, July 2011. 01-JUL-10, . : ,
- 08/30/2011 9.00 Christopher W. Hughes. The Slow Death of Japanese Techno-Nationalism? Emerging Comparative
Lessons for China's Defense Production,
Journal of Strategic Studies, Special Issue, July 2011. 01-JUL-10, . : ,
- 08/30/2011 8.00 Tai Ming Cheung. The Chinese Defense Economy's Long March from Imitation to Innovation,
Journal of Strategic Studies, Special Issue, July 2011. 01-JUL-11, . : ,
- 10/01/2014 43.00 Cong____Cao. "Adapting to Isolation: Dilemmas of China's Technological Development in the 1960's and
1970's",
Historical Influence of Contemporary Chinese Grand Strategic Thinking on Science and Technology,
University of California, San Diego, La Jolla, California, October 18, 2013. 18-OCT-13, . : ,
- 10/01/2014 45.00 Tai Ming_Cheung. "In Search of 'Goldilocks; Balance: Competition and Coordination Between National
Security, Economic Development, and Technological Innovation in China in teh Post 1978 Reform Era",
Historical Influence of Contemporary Chinese Grand Strategic Thinking on Science and Technology,
October 17-18, 2013, University of California, San Diego Campus, La Jolla, California. . 17-OCT-13, . : ,
- 10/01/2014 46.00 Richard_Horowitz. "Debating Science and Technology in the Era of Self-Strengthening, 1860 – 1880",
Historical Influence of Contemporary Chinese Grand Strategic Thinking on Science and Technology,
October 17-18, 2013, University of California, San Diego Campus, La Jolla, California.. 17-OCT-13, . : ,
- 10/01/2014 47.00 Alice_Miller, Tai Ming_Cheung. "Military Revolutions, Revolutions in Military Affairs, and the Case of
China from the Eastern Zhuou to the Maoist Eras",
Historical Influence of Contemporary Chinese Grand Strategic Thinking on Science and Technology,
October 17-18, 2013, University of California, San Diego Campus, La Jolla, California.. 17-OCT-13, . : ,

- 10/01/2014 49.00 Pete_Suttmeier. , "Military Revolutions, Revolutions in Military Affairs, and the Case of China from the Eastern Zhou to the Maoist Eras",
Historical Influence of Contemporary Chinese Grand Strategic Thinking on Science and Technology,
October 17-18, 2013, University of California, San Diego Campus, La Jolla, California.. 17-OCT-13, . : ,
- 10/01/2014 50.00 Ezra_Vogel. "Deng Xiaoping and China's Breakthrough in Science and Education,
Historical Influence of Contemporary Chinese Grand Strategic Thinking on Science and Technology,
October 17-18, 2013, University of California, San Diego Campus, La Jolla, California.. 17-OCT-13, . : ,
- 10/01/2014 51.00 Joanna_Waley-Cohen. "Ming-Qing Receptivity to Jesuit Knowledge of Western Science and Technology",
Historical Influence of Contemporary Chinese Grand Strategic Thinking on Science and Technology,
October 17-18, 2013, University of California, San Diego Campus, La Jolla, California.. 17-OCT-13, . : ,
- 10/01/2014 52.00 Zuoyue_Wang. "The Early Republic: The Warlords, Military Technology, the New Culture Movement and the Birth of China's Scientific Community", paper presented at the Historical Influence of Contemporary Chinese Grand Strategic Thinking on Science and Technology, University of California, San Diego, La Jolla, California, October 18, 2013.,
Historical Influence of Contemporary Chinese Grand Strategic Thinking on Science and Technology,
October 17-18, 2013, University of California, San Diego Campus, La Jolla, California.. 18-OCT-13, . : ,
- 10/01/2014 53.00 Jan_Taylor. Historical Influences on China's Contemporary Science and Technology,
Historical Influence of Contemporary Chinese Grand Strategic Thinking on Science and Technology,
October 17-18, 2013. 17-OCT-14, . : ,

TOTAL: 17

Number of Peer-Reviewed Conference Proceeding publications (other than abstracts):

(d) Manuscripts

- | <u>Received</u> | <u>Paper</u> |
|------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 08/28/2015 77.00 | Eric_Anderson, Chen_Ling, Barry_Naughton. Measuring the Innovation Gap between China and the United States: An Expert Survey on the IC Design Industry, Technovation (07 2015) |
| 08/29/2012 43.00 | Zhuge Jianwei, Gu Liang, Duan Haixin. Investigating China's Online Underground Economy, IGCC Working Paper (07 2012) |
| 09/11/2012 13.00 | Dieter Ernst. China's Innovation Policy is a Wake-up Call for America, Asia Pacific Issues (05 2011) |
| 09/11/2012 41.00 | Dieter Ernst, Barry Naughton. Global Technology Sourcing in China's Integrated Circuit Design Industry. A Conceptual Framework and Preliminary Findings, East West Center Working Papers (08 2012) |

TOTAL: 4

Number of Manuscripts:

Books

Received

Book

- 08/29/2013 04.00 Jon R. Lindsay (ed.), Tai Ming Cheung (ed.), Derek S. Reveron (ed.). China and Cybersecurity: Political, Economic, and Strategic Dimensions, New York, NY: Oxford University Press, (06 2014)
- 08/29/2013 24.00 Tai Ming Cheung, Thomas G. Mahnken, Dennis J. Blasko Dennis J., Samm Tyroler-Cooper, Alison Peet, Kevin Pollpeter, Richard A. Bitzinger, Andrew L. Ross, Christopher W. Hughes. China's Emergence as a Defense Technology Power, London: Routledge, (12 2012)
- 08/30/2011 17.00 Susan L. Shirk, Qian Gang, David Bandurski, Hu Shuli, Miao Di, Zhan Fiang, Tai Ming Cheung, Benjamin L. Liebman, Daniela Stockmann, Xiao Qiang. Changing Media, Changing China, New York: Oxford University Press, (01 2011)
- 08/30/2011 18.00 Dieter Ernst. Indigenous Innovation and Globalization: The Challenge for China's Standardization Strategy, San Diego, CA: IGCC-East West Center, (06 2011)
- 08/30/2011 19.00 Bates Gill. SIPRI Yearbook 2011: Armaments, Disarmament, and International Security, Oxford: Oxford University Press, (01 2011)
- 08/31/2011 20.00 Bates Gill. Rising Star: China's New Security Diplomacy, Revised Edition, Washington, D.C.: Brookings Institute, (06 2010)
- 08/31/2011 21.00 Dieter Ernst. "Global Production and Innovation Networks," in M. Juergensmeyer and H. Anheier, eds. Encyclopedia of Global Studies , Thousand Oaks, CA: Sage Publications, (01 2011)
- 08/31/2011 22.00 Dieter Ernst, J Fagerberg, J. Hildrum. The Complex Interaction Between Global Production Networks, Digital Information Systems, and International Knowledge Transfers" in C. Antonelli, ed. Elgar Handbook on the System Dynamics of Technological Change, Northampton, VA: Edward Elgar Publishing, (08 2011)
- 08/31/2011 23.00 Bates Gill. "China as an Emergent Centre of Global Power", in Graeme P. Herd, ed., Great Powers and Strategic Stability in the 21st Century: Competing Visions of World Order, New York: Routledge, (02 2010)

TOTAL: 9

Received

Book Chapter

TOTAL:

Patents Submitted

Patents Awarded

Awards

Graduate Students

<u>NAME</u>	<u>PERCENT SUPPORTED</u>	Discipline
Ming, Ji	0.08	
Guoman, Sun	0.02	
FTE Equivalent:	0.10	
Total Number:	2	

Names of Post Doctorates

<u>NAME</u>	<u>PERCENT SUPPORTED</u>
FTE Equivalent:	
Total Number:	

Names of Faculty Supported

<u>NAME</u>	<u>PERCENT SUPPORTED</u>
FTE Equivalent:	
Total Number:	

Names of Under Graduate students supported

<u>NAME</u>	<u>PERCENT SUPPORTED</u>
FTE Equivalent:	
Total Number:	

Student Metrics

This section only applies to graduating undergraduates supported by this agreement in this reporting period

The number of undergraduates funded by this agreement who graduated during this period: 0.00

The number of undergraduates funded by this agreement who graduated during this period with a degree in science, mathematics, engineering, or technology fields:..... 0.00

The number of undergraduates funded by your agreement who graduated during this period and will continue to pursue a graduate or Ph.D. degree in science, mathematics, engineering, or technology fields:..... 0.00

Number of graduating undergraduates who achieved a 3.5 GPA to 4.0 (4.0 max scale):..... 0.00

Number of graduating undergraduates funded by a DoD funded Center of Excellence grant for Education, Research and Engineering:..... 0.00

The number of undergraduates funded by your agreement who graduated during this period and intend to work for the Department of Defense 0.00

The number of undergraduates funded by your agreement who graduated during this period and will receive scholarships or fellowships for further studies in science, mathematics, engineering or technology fields:..... 0.00

Names of Personnel receiving masters degrees

NAME

Total Number:

Names of personnel receiving PHDs

NAME

Total Number:

Names of other research staff

<u>NAME</u>	<u>PERCENT SUPPORTED</u>
Anderson, Eric	0.13
Grice, Jon	0.29
Santillanez, Robson, Elizabeth	0.23
Yang, Fan	0.37
FTE Equivalent:	1.02
Total Number:	4

Sub Contractors (DD882)

Inventions (DD882)

Scientific Progress

INTRODUCTION

From 2010 to 2015, the University of California Institute on Global Conflict and Cooperation (IGCC) conducted wide-ranging research, training, dialogues, and dissemination of the results of the Minerva funded project entitled “The Evolving Relationship Between Technology and National Security in China”. The project was called the “Study of Innovation and Technology in China” (SITC) and its purpose was to identify and investigate the forces and dynamics that are reshaping the technological landscape in China, most importantly in the defense, dual-use, and strategic sectors, and how this has impacted the country’s place in the global S&T order.

At its inception, the project covered six research projects that was set out in the original Minerva proposal:

- 1) Annual Assessments of the Reform and Modernization of Critical Sectors in China’s Defense and Dual Use Science, Technology, and Innovation (STI) Base.
- 2) Comparing China’s Approach to Technology Development Defense Industrialization, and the Forging of a Dual-Use Base with Latecomers and Peer Competitors.
- 3) Analysis of the Political Economy of China’s Defense S&T and Technological Rise.
- 4) China’s Technological Development and the Implications for the U.S., European and International Technology Trade and Policies.
- 5) The Nature of the Structures, Processes, and Leaderships of the Chinese Civilian and Defense S&T Systems.
- 6) The Historical Influences on Chinese Grand Strategic Thinking on Science and Technology.

The project also included the development of a Relational Database Analysis System, and the training of students and junior academics in an annual summer training workshop.

ACTIVITIES AND OUTPUT

Over the course of the project, more than 60 conferences and workshops have been convened to bring scholars, analysts, government officials, industry executives, students, and other experts from the U.S. and around the world to address a wide range of issues relevant to understanding the relationship between science, technology, innovation, and security in China. There has been a proliferation of output, which includes:

•3 published peer-reviewed books: 1) Tai Ming Cheung (ed), *China’s Emergence as a Defense Technology Power*. (London: Routledge, 2013); 2) Tai Ming Cheung (ed), *Forging China’s Military Might: A New Framework for Assessing Science, Technology, and the Role of Innovation* (Baltimore, MD: John Hopkins University Press 2014); and 3) Jon Lindsay, Tai Ming Cheung, and Derek Reviron (eds.). *China and Cybersecurity* (Oxford: Oxford University Press. 2015).

•3 manuscripts under preparation for publication in a peer review outlet (either university press or scholarly journal: 1) Tai Ming Cheung (ed.) *Structure, Process, and Leadership of the Chinese Science and Technology System*; 2) *Historical Influences on Contemporary Chinese Grand Strategic Thinking on Science and Technology*; and 3) *The Human Capital Base in Chinese Defense Science, Technology, and Innovation*.

•2 special issues in scholarly peer-reviewed journals: 1) Tai Ming Cheung and Bates Gill (eds), “Trade Versus Security: How Countries Balance Technology Transfers with China,” *Journal of East Asian Studies*, Vol. 13, No. 3, Sept.-Dec. 2013; and 2) Tai Ming Cheung (ed). *China’s Emergence as a Defense Technological Power: Special Issue of the Journal of Strategic Studies*, 34 (3), June 2011.

•5 annual compendiums on the Chinese defense industry: 1) *The Rise of the Chinese Defense Economy* (2011); 2) *New Perspectives on the Chinese Defense Economy* (2012); 3) *The Chinese Economy Takes Off: Sector-By-Sector Assessments and the Role of Military End Users* (2013); 4) *Getting to Innovation: Assessing China’s Defense Research, Development, and Acquisitions System* (2014), and 5) *The Human Dimension of China’s Defense Science, Technology, and Innovation System* (2015).

•Occasional monographs published by IGCC: Dieter Ernst, *Indigenous Innovation and Globalization: The Challenge for China’s Standardization Strategy*, (UC Institute on Global Conflict and Cooperation; La Jolla, CA and East-West Center, Honolulu, HI 2011).

•SITC bulletin and news analysis reports: The SITC Bulletin is a weekly email newsletter that provides a concise yet comprehensive selection of the most important English and Chinese language reporting on Chinese science, technology, and innovation issues ranging from official policy announcements and leadership activity to corporate news, project updates, and

analysis of key developments by leading experts. Special topics of news analysis include HPC and Oil Security in China (January 2014); China's Space Robotic Arm Programs (October 2013); The Tianhe-2 Supercomputer: Less than Meets the Eye? (July 2013); China's Dream Army (June 2013); Additive Manufacturing in China: Aviation and Aerospace Applications (May 2013); Additive Manufacturing in China: Threats, Opportunities, and Developments (May 2013); Competition and Cooperation: The Story Behind the Y-20 Maiden Flight (March 2013); University of Strathclyde and CALT Launch Joint Laboratory (March 2013); and China's Second Ballistic Missile Defense Test: A Search for Strategic Stability (February 2013).

- Conference reports from special policy workshops: 1) SITC-U.S. Naval War College workshop on Changing Military Dynamics in East Asia: Grand Strategic and Technological Drivers and the Implications for U.S. and Regional Security (September 12-13, 2011); and 2) U.S. Naval War College-SITC Conference on "Rich Region, Strong States: The Political Economy of Security in Asia" (November 4-5, 2012) at the University of California San Diego.

- Dissemination within the DOD and the U.S. government: The principal investigator, Dr. Tai Ming Cheung, has conducted an extensive number of briefings and workshops with senior policy officials, DOD analysts, and research specialists across the DOD and other parts of the US government's national security establishment during the course of the project. Institutions that he has briefed to include: OSD, PACOM, NASIC, US Navy Pacific Fleet, US Navy Third Fleet, US Navy Pacific Surface HQ, DARPA, ATL, ONI, NSA, and ONA. Among senior officials that he has briefed to include the director of DARPA, PACOM commander and deputy commander, PACFLT commander, and Assistant Secretary for Defense Research and Engineering.

- Development of human talent: The project has actively sought to nurture a new generation of highly promising graduate students, early career academics, and government analysts to be knowledgeable and work on Chinese security and technology-related issues. This activity has been carried out through the SITC annual summer training program, extensive outreach and training activities with the academic and government communities, and the hiring of graduate students at the Masters and PhD level at IGCC as student researchers. The summer training course was held annually between 2010 and 2014 and provided in-depth and rigorous training to more than 120 participants from academia, the U.S. government and military services, and industry. More than half of the attendees were U.S. government and military personnel from numerous agencies including the Defense Department, intelligence community, State Department, and U.S. Congressional research outlets. Here are detailed statistics for the summer course:

(SEE TABLE INSERT IN THE REPORT DOCUMENT ATTACHMENT SUBMITTED)

A number of graduate students who attended the summer training course have now become faculty at universities in the U.S. and elsewhere in the world and are working on Chinese security and technology issues as a result of attending the course. They include:

- Adam Liff, Assistant Professor, School of Global and International Studies, Indiana University.
- Alanna Krolkowski, Visiting Professor of Modern Chinese Society and Economy, Universität Göttingen, Germany.
- Jon Lindsay, Assistant Professor, University of Toronto Munk School.
- Michael Raska, Assistant Professor, S. Rajaratnam School of International Studies, Nanyang Technological University, Singapore.
- William Norris, Assistant Professor, The Bush School of Government and Public Service, Texas A&M University.

During the course of the grant, IGCC hired 79 UCSD graduate students as student researchers, the large majority of whom were masters students and most of whom have since graduated. Another 11 undergraduate students were hired, along with 2 post-doctoral students.

OUTREACH WITH CHINESE ENTITIES

The SITC project has had considerable success in forging cooperative ties with Chinese civilian and military-affiliated academic and research entities that focus on STI issues. Cooperation has included scholar exchanges, joint conferences, joint research projects with the following institutions:

- National University for Defense Technology
- Tsinghua University
- Chinese Academy of Sciences
- China Academy of Science and Technology Development (Ministry of Science and Technology think-tank)
- Central University of Finance & Economics
- Beijing University of Posts & Telecoms

RESEARCH INSIGHTS FROM THE SITC PROJECT

The SITC project has made substantial accomplishments across a broad range of activities that have furthered the institutional knowledge of China's national, defense, and dual-use STI system, developed methodologies for addressing this hard target issue, and trained the next generation of researchers in using these new methodologies to generate analytically sound and policy relevant analysis. These include:

- Improving analytical rigor and developing new methodological tools: The SITC project has pioneered efforts to impose analytically rigorous and sophisticated methodological tools to assess defense STI activities. This includes the development of a new analytical framework for analyzing defense innovation. This framework was developed primarily by examining China, but has broader applicability for assessing other latecomer countries.

- Development of defense science, technology, and innovation studies as a new field of inter-disciplinary academic/policy study: The SITC project has played a central role in cultivating the study of Chinese defense STI as a new and important area of research. Before the SITC program, research on Chinese defense STI issues was poorly developed and isolated. The SITC program has significantly expanded the output of research by producing a pioneering series of publications, attracted established and young analysts to work in this area, and brought together experts from a variety of disciplines to forge an inter-disciplinary approach.

- Important new insights into the workings, organization, and drivers of Chinese defense STI: The SITC project has contributed numerous analytical insights into the organization, workings, and impact of the Chinese national and defense STI systems that is helping to deepen understanding of this opaque establishment. A few highlights would include:

1. Identifying previously unknown and overlooked leadership organs guiding major defense strategic S&T projects;
2. Uncovering the profound impact of the 1999 U.S. bombing of the Chinese Embassy in Belgrade on China's strategic and defense STI programs;
3. Providing regular surveys of China's defense and dual-use industries (shipbuilding, aviation, space and missile, electronics, nuclear, and ordnance), which provides longitudinal perspectives into trends in the development of these strategic sectors;
4. Charting the development of a dual-use civil-military economy;
5. Probing the nature of the Chinese cybersecurity ecosystem, especially identifying key actors and its structure and process;
6. Providing a detailed examination of China's efforts to become a leading player in high-performance computing and assessing its long-term prospects in leapfrogging the United States to become the first country to advance to exascale computing.
7. Explaining the structure and process of high-level decision-making on Chinese science and technology.
8. Quantifying how much China invests in defense science and technology research and development, including from government allocations and corporate contributions.

Full details of the research can be found in the publications that have come out of the project, but a number of these research efforts will be highlighted here.

DEFENSE INNOVATION THEORY

The Chinese defense science, technology and innovation (DSTI) system is making a concerted effort to build strong and capable indigenous innovation capacity to join the world's top tier of military technological powers. Ample access to financial, human, and research resources; strong political support; inflows of foreign technologies and know-how; and the introduction of advanced modes of governance, market competition, and management are producing significant progress, although from a low base. But long-term success is far from assured, given the daunting structural bottlenecks stemming from a long history of Socialist central planning.

A critical deficiency with the examination of Chinese defense issues has been that much of the research output has been descriptive, non-theoretical, and narrowly focused on China with little comparative perspective. An important goal of our research has been the development and use of conceptual frameworks of analysis from other fields of study to help define the nature of Chinese defense innovation; to understand the key drivers shaping its evolution, and to locate China's place in the sectoral, national and global defense industrial and innovation systems. This has resulted in development of an analytical framework composed of a number of lenses through which to view the inputs, processes, and outputs of innovation: 1) the components of innovation; technology, doctrine, and organization; 2) the capacity to innovate; 3) the process of innovation: speculation, experimentation and implementation; 4) the degree of innovation from duplicative imitation to radical innovation; 5) the scope of innovation, and 6) systems innovation.

A key contribution of this work has been the development of a rigorous definition of defense innovation including a typology of different types of innovation, and analysis of how this applies to China. Defense innovation is the transformation of ideas and knowledge into new or improved products, processes, and services for military and dual-use applications and military innovation is intended to enhance the military's ability to prepare for, fight, and win wars. We identified seven types of imitation or innovation models that can be used to track the evolution in China's defense technological development ranging from duplicative imitation to radical or disruptive innovation. Where states and their defense innovation strategies fit into this typology

depend on a number of key structural factors: 1) their level and approach to economic and technological development; 2) their external security situation; and 3) the nature of their integration in the global economy and technological order. In applying the framework to China, our assessment is that China's progress in the development of its innovation capabilities is more incremental than discontinuous. However, areas that could yet yield disruptive surprises include anti-ship ballistic missiles, information warfare, and anti-satellite weaponry.

Work conducted in this area of investigation yielded numerous papers presented at conferences, IGCC policy brief publications, and a book entitled, "Forging China's Military Might: A New Framework for Assessing Innovation," edited by Tai Ming Cheung, 2011, Johns Hopkins University Press.

UNDERSTANDING CHINESE APPROACHES TO RESEARCH, DEVELOPMENT, AND ACQUISITION

China's defense industry has been introducing new weapon systems at a faster rate than at any other time in its history. From new fighter aircraft to new rocket launchers to new types of information systems, China's once moribund defense industry can now manufacture increasingly capable weapons and equipment. A critical component of China's weapons programs is its research, development and acquisition (RDA) system.

In order to develop a better understanding of Chinese approaches to RDA, a conference was held in July 2013 to examine China's RDA process, including analysis of the global RDA processes, the role of high-risk/high-reward technology development organizations, and examination of cross-cutting issues in the Chinese RDA system using case studies. Using an RDA framework that was tested using case studies, key innovation factors were identified, including the role of technology transfer; aversion to risk; technology push vs. demand pull, and critical organizations and personnel. These case studies identified a number of themes revealing that in most weapons programs, China follows a risk mitigation approach to weapons development to include borrowing from foreign sources and measured improvements in technology rather than significant leaps in innovative capabilities. In addition, China's efforts to assimilate foreign technology were examined. Findings from the conference were published in the SITC 2014 annual compendium edited by Kevin Pollpeter called *Getting to Innovation: Assessing China's Defense Research, Development, and Acquisitions System*.

HISTORICAL INFLUENCES ON CONTEMPORARY CHINESE GRAND STRATEGIC THINKING ON SCIENCE AND TECHNOLOGY

Work was conducted to understand the dilemmas, debates, and approaches undertaken in the late imperial era—from the later Ming (1368-1644) and Manchu Qing (1636-1912) regimes—and in the Republican and early PRC periods as a means to illuminate the foundations of contemporary Chinese grand strategy and the relationship of S&T development to national security. Researchers sought to assess the validity of longstanding conventional interpretations and to dissect both the continuities and discontinuities in approach to issues of technological development among successive Chinese leaderships from the 16th century down to the present day. A conference focusing on this topic was convened by Alice Miller (Hoover Institution) and Tai Ming Cheung in October, 2013.

Specific topics examined included: 1) Chinese culture in the area of military and technology innovation; 2) Science, technology and the Modern Chinese State; 3) Military revolutions, revolutions in military affairs in China; 4) The influence of Chinese leaders in shaping science and technology development; 5) Competition and coordination between national security, economic development, and technological innovation in China in the post-1978 reform era; 6) Ming-Qing receptivity to Jesuit knowledge of Western science and technology; 7) The self-strengthening movement's strategic debates over foreign technology; 8) The Early Republic: the warlords, military, technology; 9) The new culture movement and the birth of China's scientific community; 10) The Nanjing Republican State and S&T in the national interest; 11) The implications of adopting the Soviet-model of technological development, and 12) Adapting to isolation: dilemmas of technological development in the 1960's and 1970's. Final work is continuing toward the submission of these papers for university press publication.

THE HUMAN CAPITAL BASE IN CHINESE DEFENSE SCIENCE, TECHNOLOGY, AND INNOVATION

Work related to the role of human factors in Chinese defense, science, technology and innovation (STI) was conducted in an effort to bring human agency more prominently into the study of STI. While it may seem obvious that human factors play an indispensable role in the conduct of defense science, these factors are generally overlooked in the study of defense and civilian STI activities. A central issue that was explored is the relationship between human agency and structural factors as China's defense S&T system steadily has changed from a weak to an increasingly robust apparatus, and how this impacts its innovation capabilities and development trajectories. Based upon the outcomes of a conference on "Personalities, Talent, and the Human Capital Base" held in August, 2014. A total of 10 papers were presented and reviewed by experts on various sectors, including higher education, the cyber workforce, and science and engineering communities. Participants included members of the government, private/non-profit sector, and academic communities, university faculty, and PhD and masters-level graduate students.

Topics covered at the conference included: 1) an examination of the human dimension in Chinese defense science, technology and innovation; 2) an overview of China's efforts to cultivate its human talent base in science and technology; 3) a survey of China's S&T human talents program; 4) China's defense R&D management system; 5) the roles and influence of chief commanders and chief designers; 6) the political and bureaucratic influence of the defense industrial lobby in Chinese elite politics; 7) the role of defense science and technology in higher education establishments; 8) institutional mechanisms to enable creativity and innovation; 9) the cyber human capital base; assessing China's scientific and engineering leaders in defense science and technology, and 10) scientific communities in the Chinese defense S&T system.

A compendium of policy briefs was published by IGCC in 2015 based upon the conference papers. Work is continuing to produce a high-quality scholarly publication based on this research.

CHINA AND CYBERSECURITY

Cybersecurity is an important but neglected factor for understanding Chinese technological innovation. This project explored this topic during two conferences that brought together Chinese and western scholars and policy analysts from technical and social science disciplines. The discussions led toward continued work on the subject, and the development of a research network in China, including a relationship with the Beijing University of Posts and Telecommunications (BUPT). We also hosted visits from two Chinese scholars from BUPT, and one IGCC scholar provided lectures and participated in an academic symposium in China on internet privacy and security. This work has been leveraged to create a book edited by Jon Lindsay, Tai Ming Cheung, and Derek Revere, published by Oxford University press in 2015. This was the first scholarly volume assessing an issue of tremendous contemporary importance in the U.S-Sino relationship and featuring international and interdisciplinary contributions. Our cybersecurity-related output is an example of how unexpected results can have highly productive outcomes, although they were not anticipated at the start of the project.

DATABASE

A key component of the SITC project has been the development of a "Relational Database Analysis System," which has been overseen by David Meyer at UC San Diego. The principal aim of the database system is to support graph-theoretic social network analysis to characterize the positions of individuals, organizations, projects and technologies within networks, as well as provide general characterizations of the nature of these networks. This is the only database of its kind focused exclusively on Chinese science and technology programs, personnel, and organizations.

Entities in the current version of the database include organizations, corporations, universities, individuals, awards, conferences, projects, publications (each with relevant attributes). Data is collected and entered by IGCC staff, individually sourced, and carefully reviewed for accuracy and consistency. Data collection sources and methods include the use of an extensive array of publically accessible Chinese language materials, Chinese language journals, Chinese corporate databases and other external databases with relevant data as well as field research.

To date we have collected data pertaining to more than 1,600 S&T organizations, 12,000 Chinese corporations, 22,000 individuals, 400 S&T projects, 290 S&T conferences, 210 publications and 610 universities. Furthermore, we have collected and recorded essential information such as biographical information, educational background, financial performance, evolution history, and funding related to these entities in the database. During the past year, a major focus has been the completion of work to prepare the database for public access. This included the input of information regarding board members of Chinese companies in the Shanghai and Shenzhen stock markets; and the merging of Dr. Victor Shih's dataset on China Central Committee members into our database.

The Relational Database interface has been reviewed and modified periodically to adjust for additional data and user requirements. To date the user interface has been structured in a user-friendly manner that is rich in data presentation, and is ready for public access. In addition to basic search functions on organizations, corporations and individuals, we have also developed advanced functions, such as options for the display of relational personnel networks, and summaries of data for listed companies, to enhance users' capabilities to do heavy data oriented research and network analysis.

The database has become a valuable tool for scholars, researchers and government officials to access comprehensive information of the Chinese S&T systems. With additional effort, the database system can be further used to conduct analysis on Chinese corporations and the capital market, including:

- 1) Characteristics, structure and changes of board members for all listed companies, and
- 2) Shareholding structure of listed companies, particularly companies owned or partially owned by the state-owned enterprises.

The database would be useful for research on topics such as the securitization of Chinese state assets, governmental influence on corporations, and civil-military trends in the capital market. Examples demonstrating some of the current functions of the database are included in the report attachment.

(SEE TABLE INSERTS IN THE REPORT DOCUMENT ATTACHMENT SUBMITTED)

CONCLUSION

The SITC project has been a foundational catalyst in the development of academic research on defense science, technology, and innovation, and especially focused on China, as a methodologically rigorous and well-informed field of academic and policy study. Through wide-ranging field research, including engagement with Chinese civilian and military organizations specializing in science and technology, and detailed examination of Chinese language sources, the SITC project has yielded many insights and new sources of information. Moreover, the project has pioneered academically rigorous and sophisticated methodological tools and approaches. This includes the development of new analytical frameworks for analyzing defense innovation, better defining what is meant by innovation, and the development of inter-disciplinary approaches to research between the sciences and social sciences and between different fields in the social sciences including political science, economics, business studies, and security studies.

Outcomes including publications, presentations and student training metrics have been submitted with our progress reports in previous years. Work will be continued to prepare outstanding manuscripts for publication. With the receipt of a new ARO grant titled, "Understanding China's Efforts to Become a Global Defense Science, Technology and Innovation Leader," effective July, 2015, we are able to build upon the work conducted with this SITC Minerva grant for another three years. The new grant will focus on: 1) China's Defense Research, Development and Acquisition System; 2) Annual Review of China's Defense Industrial Base, and 3) Applying Lessons Learned from China to Understand How Other Countries Become Military Technological and Industrial Powers.

Technology Transfer

Cheung, Tai Ming, "Making and Implementing Chinese Military and Naval Long-Term Armament Development Strategies and Plans", presentation to the U.S. Navy Third Fleet, November 9, 2015.

ATTACHMENT: Scientific Progress and Accomplishments Report with Tables Included

Final Report of the Minerva Project on “The Evolving Relationship Between Technology and National Security in China”, 2010-2015

Introduction

From 2010 to 2015, the University of California Institute on Global Conflict and Cooperation (IGCC) conducted wide-ranging research, training, dialogues, and dissemination of the results of the Minerva funded project entitled “The Evolving Relationship Between Technology and National Security in China”. The project was called the “Study of Innovation and Technology in China” (SITC) and its purpose was to identify and investigate the forces and dynamics that are reshaping the technological landscape in China, most importantly in the defense, dual-use, and strategic sectors, and how this has impacted the country’s place in the global S&T order.

At its inception, the project covered six research projects that was set out in the original Minerva proposal:

- 1) Annual Assessments of the Reform and Modernization of Critical Sectors in China’s Defense and Dual Use Science, Technology, and Innovation (STI) Base.
- 2) Comparing China’s Approach to Technology Development Defense Industrialization, and the Forging of a Dual-Use Base with Latecomers and Peer Competitors.
- 3) Analysis of the Political Economy of China’s Defense S&T and Technological Rise.
- 4) China’s Technological Development and the Implications for the U.S., European and International Technology Trade and Policies.
- 5) The Nature of the Structures, Processes, and Leaderships of the Chinese Civilian and Defense S&T Systems.
- 6) The Historical Influences on Chinese Grand Strategic Thinking on Science and Technology.

The project also included the development of a Relational Database Analysis System, and the training of students and junior academics in an annual summer training workshop.

Activities and Output

Over the course of the project, more than 60 conferences and workshops have been convened to bring scholars, analysts, government officials, industry executives, students, and other experts from the U.S. and around the world to address a wide range of issues relevant to understanding the relationship between science, technology, innovation, and security in China. There has been a proliferation of output, which includes:

- **3 published peer-reviewed books:** 1) Tai Ming Cheung (ed), *China’s Emergence as a Defense Technology Power*. (London: Routledge, 2013); 2) Tai Ming Cheung (ed), *Forging China’s Military Might: A New Framework for Assessing Science, Technology, and the Role of Innovation* (Baltimore, MD: John Hopkins University Press 2014); and 3) Jon Lindsay, Tai Ming Cheung, and Derek Reveron (eds.). *China and Cybersecurity* (Oxford: Oxford University Press. 2015).

- **3 manuscripts under preparation for publication in a peer review outlet (either university press or scholarly journal):** 1) Tai Ming Cheung (ed.) *Structure, Process, and Leadership of the Chinese Science and Technology System*; 2) *Historical Influences on Contemporary Chinese Grand Strategic Thinking on Science and Technology*; and 3) *The Human Capital Base in Chinese Defense Science, Technology, and Innovation*.
- **2 special issues in scholarly peer-reviewed journals:** 1) Tai Ming Cheung and Bates Gill (eds), "Trade Versus Security: How Countries Balance Technology Transfers with China," *Journal of East Asian Studies*, Vol. 13, No. 3, Sept.-Dec. 2013; and 2) Tai Ming Cheung (ed). *China's Emergence as a Defense Technological Power: Special Issue of the Journal of Strategic Studies*, 34 (3), June 2011.
- **5 annual compendiums on the Chinese defense industry:** 1) *The Rise of the Chinese Defense Economy* (2011); 2) *New Perspectives on the Chinese Defense Economy* (2012); 3) *The Chinese Economy Takes Off: Sector-By-Sector Assessments and the Role of Military End Users* (2013); 4) *Getting to Innovation: Assessing China's Defense Research, Development, and Acquisitions System* (2014), and 5) *The Human Dimension of China's Defense Science, Technology, and Innovation System* (2015).
- **Occasional monographs published by IGCC:** Dieter Ernst, *Indigenous Innovation and Globalization: The Challenge for China's Standardization Strategy*, (UC Institute on Global Conflict and Cooperation; La Jolla, CA and East-West Center, Honolulu, HI 2011).
- **SITC bulletin and news analysis reports:** The SITC Bulletin is a weekly email newsletter that provides a concise yet comprehensive selection of the most important English and Chinese language reporting on Chinese science, technology, and innovation issues ranging from official policy announcements and leadership activity to corporate news, project updates, and analysis of key developments by leading experts. Special topics of news analysis include HPC and Oil Security in China (January 2014); China's Space Robotic Arm Programs (October 2013); The Tianhe-2 Supercomputer: Less than Meets the Eye? (July 2013); China's Dream Army (June 2013); Additive Manufacturing in China: Aviation and Aerospace Applications (May 2013); Additive Manufacturing in China: Threats, Opportunities, and Developments (May 2013); Competition and Cooperation: The Story Behind the Y-20 Maiden Flight (March 2013); University of Strathclyde and CALT Launch Joint Laboratory (March 2013); and China's Second Ballistic Missile Defense Test: A Search for Strategic Stability (February 2013).
- **Conference reports from special policy workshops:** 1) SITC-U.S. Naval War College workshop on *Changing Military Dynamics in East Asia: Grand Strategic and Technological Drivers and the Implications for U.S. and Regional Security* (September 12-13, 2011); and 2) U.S. Naval War College-SITC Conference on "Rich Region, Strong States: The Political Economy of Security in Asia" (November 4-5, 2012) at the University of California San Diego.

- Dissemination within the DOD and the U.S. government:** The principal investigator, Dr. Tai Ming Cheung, has conducted an extensive number of briefings and workshops with senior policy officials, DOD analysts, and research specialists across the DOD and other parts of the US government's national security establishment during the course of the project. Institutions that he has briefed to include: OSD, PACOM, NASIC, US Navy Pacific Fleet, US Navy Third Fleet, US Navy Pacific Surface HQ, DARPA, ATL, ONI, NSA, and ONA. Among senior officials that he has briefed to include the director of DARPA, PACOM commander and deputy commander, PACFLT commander, and Assistant Secretary for Defense Research and Engineering.
- Development of human talent:** The project has actively sought to nurture a new generation of highly promising graduate students, early career academics, and government analysts to to be knowledgeable and work on Chinese security and technology-related issues. This activity has been carried out through the SITC annual summer training program, extensive outreach and training activities with the academic and government communities, and the hiring of graduate students at the Masters and PhD level at IGCC as student researchers. The summer training course was held annually between 2010 and 2014 and provided in-depth and rigorous training to more than 120 participants from academia, the U.S. government and military services, and industry. More than half of the attendees were U.S. government and military personnel from numerous agencies including the Defense Department, intelligence community, State Department, and U.S. Congressional research outlets. Here are detailed statistics for the summer course:

SITC Summer Training Workshop Participants (2010-2014)	
Graduate Students & Junior Faculty	41
U.S. Government & Military	67
Industry (domestic and international)	16
TOTAL	124
Presentations Delivered	
Summer Training Workshops	83
Other Presentations	261
TOTAL	323

A number of graduate students who attended the summer training course have now become faculty at universities in the U.S. and elsewhere in the world and are working on Chinese security and technology issues as a result of attending the course. They include:

- Adam Liff, Assistant Professor, School of Global and International Studies, Indiana University.
- Alanna Krolikowski, Visiting Professor of Modern Chinese Society and Economy, Universität Göttingen, Germany.
- Jon Lindsay, Assistant Professor, University of Toronto Munk School.
- Michael Raska, Assistant Professor, S. Rajaratnam School of International Studies, Nanyang Technological University, Singapore.
- William Norris, Assistant Professor, The Bush School of Government and Public Service, Texas A&M University.

During the course of the grant, IGCC hired 79 UCSD graduate students as student researchers, the large majority of whom were masters students and most of whom have since graduated. Another 11 undergraduate students were hired, along with 2 post-doctoral students.

Outreach with Chinese Entities

The SITC project has had considerable success in forging cooperative ties with Chinese civilian and military-affiliated academic and research entities that focus on STI issues. Cooperation has included scholar exchanges, joint conferences, joint research projects with the following institutions:

- National University for Defense Technology
- Tsinghua University
- Chinese Academy of Sciences
- China Academy of Science and Technology Development (Ministry of Science and Technology think-tank)
- Central University of Finance & Economics
- Beijing University of Posts & Telecoms

Research Insights From the SITC Project

The SITC project has made substantial accomplishments across a broad range of activities that have furthered the institutional knowledge of China's national, defense, and dual-use STI system, developed methodologies for addressing this hard target issue, and trained the next generation of researchers in using these new methodologies to generate analytically sound and policy relevant analysis. These include:

- **Improving analytical rigor and developing new methodological tools:** The SITC project has pioneered efforts to impose analytically rigorous and sophisticated methodological tools to assess defense STI activities. This includes the development of a new analytical framework for analyzing defense innovation. This framework was

developed primarily by examining China, but has broader applicability for assessing other latecomer countries.

- **Development of defense science, technology, and innovation studies as a new field of inter-disciplinary academic/policy study:** The SITC project has played a central role in cultivating the study of Chinese defense STI as a new and important area of research. Before the SITC program, research on Chinese defense STI issues was poorly developed and isolated. The SITC program has significantly expanded the output of research by producing a pioneering series of publications, attracted established and young analysts to work in this area, and brought together experts from a variety of disciplines to forge an inter-disciplinary approach.
- **Important new insights into the workings, organization, and drivers of Chinese defense STI:** The SITC project has contributed numerous analytical insights into the organization, workings, and impact of the Chinese national and defense STI systems that is helping to deepen understanding of this opaque establishment. A few highlights would include:
 1. Identifying previously unknown and overlooked leadership organs guiding major defense strategic S&T projects;
 2. Uncovering the profound impact of the 1999 U.S. bombing of the Chinese Embassy in Belgrade on China's strategic and defense STI programs;
 3. Providing regular surveys of China's defense and dual-use industries (shipbuilding, aviation, space and missile, electronics, nuclear, and ordnance), which provides longitudinal perspectives into trends in the development of these strategic sectors;
 4. Charting the development of a dual-use civil-military economy;
 5. Probing the nature of the Chinese cybersecurity ecosystem, especially identifying key actors and its structure and process;
 6. Providing a detailed examination of China's efforts to become a leading player in high-performance computing and assessing its long-term prospects in leapfrogging the United States to become the first country to advance to exascale computing.
 7. Explaining the structure and process of high-level decision-making on Chinese science and technology.
 8. Quantifying how much China invests in defense science and technology research and development, including from government allocations and corporate contributions.

Full details of the research can be found in the publications that have come out of the project, but a number of these research efforts will be highlighted here.

Defense Innovation Theory

The Chinese defense science, technology and innovation (DSTI) system is making a concerted effort to build strong and capable indigenous innovation capacity to join the world's top tier of military technological powers. Ample access to financial, human, and research resources; strong political support; inflows of foreign technologies and know-how; and the introduction of advanced modes of governance, market competition, and management are producing significant progress, although from a low base. But long-term success is far from assured, given the daunting structural bottlenecks stemming from a long history of Socialist central planning.

A critical deficiency with the examination of Chinese defense issues has been that much of the research output has been descriptive, non-theoretical, and narrowly focused on China with little comparative perspective. An important goal of our research has been the development and use of conceptual frameworks of analysis from other fields of study to help define the nature of Chinese defense innovation; to understand the key drivers shaping its evolution, and to locate China's place in the sectoral, national and global defense industrial and innovation systems. This has resulted in development of an analytical framework composed of a number of lenses through which to view the inputs, processes, and outputs of innovation: 1) the components of innovation: technology, doctrine, and organization; 2) the capacity to innovate; 3) the process of innovation: speculation, experimentation and implementation; 4) the degree of innovation from duplicative imitation to radical innovation; 5) the scope of innovation, and 6) systems innovation.

A key contribution of this work has been the development of a rigorous definition of defense innovation including a typology of different types of innovation, and analysis of how this applies to China. Defense innovation is the transformation of ideas and knowledge into new or improved products, processes, and services for military and dual-use applications and military innovation is intended to enhance the military's ability to prepare for, fight, and win wars. We identified seven types of imitation or innovation models that can be used to track the evolution in China's defense technological development ranging from duplicative imitation to radical or disruptive innovation. Where states and their defense innovation strategies fit into this typology depend on a number of key structural factors: 1) their level and approach to economic and technological development; 2) their external security situation; and 3) the nature of their integration in the global economy and technological order. In applying the framework to China, our assessment is that China's progress in the development of its innovation capabilities is more incremental than discontinuous. However, areas that could yet yield disruptive surprises include anti-ship ballistic missiles, information warfare, and anti-satellite weaponry.

Work conducted in this area of investigation yielded numerous papers presented at conferences, IGCC policy brief publications, and a book entitled, "Forging China's Military Might: A New Framework for Assessing Innovation," edited by Tai Ming Cheung, 2011, Johns Hopkins University Press.

Understanding Chinese Approaches to Research, Development, and Acquisition

China's defense industry has been introducing new weapon systems at a faster rate than at any other time in its history. From new fighter aircraft to new rocket launchers to new types of information systems, China's once moribund defense industry can now manufacture increasingly capable weapons and equipment. A critical component of China's weapons programs is its research, development and acquisition (RDA) system.

In order to develop a better understanding of Chinese approaches to RDA, a conference was held in July 2013 to examine China's RDA process, including analysis of the global RDA processes, the role of high-risk/high-reward technology development organizations, and examination of cross-cutting issues in the Chinese RDA system using case studies. Using an RDA framework that was tested using case studies, key innovation factors were identified, including the role of

technology transfer; aversion to risk; technology push vs. demand pull, and critical organizations and personnel. These case studies identified a number of themes revealing that in most weapons programs, China follows a risk mitigation approach to weapons development to include borrowing from foreign sources and measured improvements in technology rather than significant leaps in innovative capabilities. In addition, China's efforts to assimilate foreign technology were examined. Findings from the conference were published in the SITC 2014 annual compendium edited by Kevin Pollpeter called *Getting to Innovation: Assessing China's Defense Research, Development, and Acquisitions System*.

Historical Influences on Contemporary Chinese Grand Strategic Thinking on Science and Technology

Work was conducted to understand the dilemmas, debates, and approaches undertaken in the late imperial era—from the later Ming (1368-1644) and Manchu Qing (1636-1912) regimes—and in the Republican and early PRC periods as a means to illuminate the foundations of contemporary Chinese grand strategy and the relationship of S&T development to national security. Researchers sought to assess the validity of longstanding conventional interpretations and to dissect both the continuities and discontinuities in approach to issues of technological development among successive Chinese leaderships from the 16th century down to the present day. A conference focusing on this topic was convened by Alice Miller (Hoover Institution) and Tai Ming Cheung in October, 2013.

Specific topics examined included: 1) Chinese culture in the area of military and technology innovation; 2) Science, technology and the Modern Chinese State; 3) Military revolutions, revolutions in military affairs in China; 4) The influence of Chinese leaders in shaping science and technology development; 5) Competition and coordination between national security, economic development, and technological innovation in China in the post-1978 reform era; 6) Ming-Qing receptivity to Jesuit knowledge of Western science and technology; 7) The self-strengthening movement's strategic debates over foreign technology; 8) The Early Republic: the warlords, military, technology; 9) The new culture movement and the birth of China's scientific community; 10) The Nanjing Republican State and S&T in the national interest; 11) The implications of adopting the Soviet-model of technological development, and 12) Adapting to isolation: dilemmas of technological development in the 1960's and 1970's. Final work is continuing toward the submission of these papers for university press publication.

The Human Capital Base in Chinese Defense Science, Technology, and Innovation

Work related to the role of human factors in Chinese defense, science, technology and innovation (STI) was conducted in an effort to bring human agency more prominently into the study of STI. While it may seem obvious that human factors play an indispensable role in the conduct of defense science, these factors are generally overlooked in the study of defense and civilian STI activities. A central issue that was explored is the relationship between human agency and structural factors as China's defense S&T system steadily has changed from a weak to an increasingly robust apparatus, and how this impacts its innovation capabilities and development trajectories. Based upon the outcomes of a conference on "Personalities, Talent, and the Human Capital Base" held in August, 2014. A total of 10 papers were presented and reviewed by experts on various sectors, including higher education, the cyber workforce, and science and engineering

communities. Participants included members of the government, private/non-profit sector, and academic communities, university faculty, and PhD and masters-level graduate students.

Topics covered at the conference included: 1) an examination of the human dimension in Chinese defense science, technology and innovation; 2) an overview of China's efforts to cultivate its human talent base in science and technology; 3) a survey of China's S&T human talents program; 4) China's defense R&D management system; 5) the roles and influence of chief commanders and chief designers; 6) the political and bureaucratic influence of the defense industrial lobby in Chinese elite politics; 7) the role of defense science and technology in higher education establishments; 8) institutional mechanisms to enable creativity and innovation; 9) the cyber human capital base; assessing China's scientific and engineering leaders in defense science and technology, and 10) scientific communities in the Chinese defense S&T system.

A compendium of policy briefs was published by IGCC in 2015 based upon the conference papers. Work is continuing to produce a high-quality scholarly publication based on this research.

China and Cybersecurity

Cybersecurity is an important but neglected factor for understanding Chinese technological innovation. This project explored this topic during two conferences that brought together Chinese and western scholars and policy analysts from technical and social science disciplines. The discussions led toward continued work on the subject, and the development of a research network in China, including a relationship with the Beijing University of Posts and Telecommunications (BUPT). We also hosted visits from two Chinese scholars from BUPT, and one IGCC scholar provided lectures and participated in an academic symposium in China on internet privacy and security. This work has been leveraged to create a book edited by Jon Lindsay, Tai Ming Cheung, and Derek Reviron, published by Oxford University press in 2015. This was the first scholarly volume assessing an issue of tremendous contemporary importance in the U.S-Sino relationship and featuring international and interdisciplinary contributions. Our cybersecurity-related output is an example of how unexpected results can have highly productive outcomes, although they were not anticipated at the start of the project.

Database

A key component of the SITC project has been the development of a "Relational Database Analysis System," which has been overseen by David Meyer at UC San Diego. The principal aim of the database system is to support graph-theoretic social network analysis to characterize the positions of individuals, organizations, projects and technologies within networks, as well as provide general characterizations of the nature of these networks. This is the only database of its kind focused exclusively on Chinese science and technology programs, personnel, and organizations.

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- 2) Shareholding structure of listed companies, particularly companies owned or partially owned by the state-owned enterprises.

The database would be useful for research on topics such as the securitization of Chinese state assets, governmental influence on corporations, and civil-military trends in the capital market. Examples demonstrating some of the current functions of the database are included in Attachments A1- A3 at the end of this narrative.

Conclusion

The SITC project has been a foundational catalyst in the development of academic research on defense science, technology, and innovation, and especially focused on China, as a methodologically rigorous and well-informed field of academic and policy study. Through wide-ranging field research, including engagement with Chinese civilian and military organizations specializing in science and technology, and detailed examination of Chinese language sources, the SITC project has yielded many insights and new sources of information. Moreover, the project has pioneered academically rigorous and sophisticated methodological tools and approaches. This includes the development of new analytical frameworks for analyzing defense innovation, better defining what is meant by innovation, and the development of interdisciplinary approaches to research between the sciences and social sciences and between

different fields in the social sciences including political science, economics, business studies, and security studies.

Outcomes including publications, presentations and student training metrics have been submitted with our progress reports in previous years. Work will be continued to prepare outstanding manuscripts for publication. With the receipt of a new ARO grant titled, “Understanding China’s Efforts to Become a Global Defense Science, Technology and Innovation Leader,” effective July, 2015, we are able to build upon the work conducted with this SITC Minerva grant for another three years. The new grant will focus on: 1) China’s Defense Research, Development and Acquisition System; 2) Annual Review of China’s Defense Industrial Base, and 3) Applying Lessons Learned from China to Understand How Other Countries Become Military Technological and Industrial Powers.

List of Appendixes

ATTACHMENT A-1: Biographical Data (Partial) on Minister of Ministry of Science and Technology of People's Republic of China, Wan Gang

ATTACHMENT A-2: Corporation Profile (Partial) of Aviation Industry Corporation of China_Relational Network of State Administration for Science, Technology, and Industry for National Defense Director Xu Dazhe

ATTACHMENT A-3: Relational Network of State Administration for Science, Technology, and Industry for National Defense Director Xu Dazhe

ATTACHMENT A-1**Biographical Data (Partial) on Minister of Ministry of Science and Technology of People's Republic of China, Wan Gang**

Future China-Minerva Database

—Where we learn about China—

HOMESEARCHOVERVIEWNEWSLETTERABOUTCONTACT US

万钢(Wan Gang)

Male 汉族

Born: 1952-08 Age: 63

Birth province: 上海 Hometown: Shanghai

[Chinese Academy of Science and Technology for Development](#) 院长 2007 to Present

[Ministry of Science and Technology](#) 部长 2007 to Present

[China Zhi Gong Party](#) 党委书记/书记/主席 2007 to Present

[China Zhi Gong Party](#) 委员/成员 2005 to Present

[State Council S&T and Education Group](#) 委员/成员 Present

Names

Chinese Name	万钢	funding	
English Name	Wan Gang	funding	

Employment

Organization/Corporation	Position	From	To	More Info
China Zhi Gong Party	党委书记/书记/主席	2007	Present	
Chinese Academy of Science and Technology for Development	院长	2007	Present	
Ministry of Science and Technology	部长	2007	Present	
China Zhi Gong Party	委员/成员	2005	Present	
State Council S&T and Education Group	委员/成员		Present	
Chinese Peoples Political Consultative Conference	党委副书记/副书记/副主席	2008	2013	
Shanghai Association for Science and Technology	副会长	2006	2011	
Chinese Peoples Political Consultative Conference	常委委员	2003	2008	
China Zhi Gong Party	党委副书记/副书记/副主席	2006	2007	
Tongji University	院长	2004	2007	
Tongji University	副院长	2003	2004	
Tongji University	主任	2001	2004	
Tongji University	院长	2001	2004	
Tongji University	秘书	2001	2004	
State Council of the PRC	其它	2000	2000	
	工程师	1991	1996	
Tongji University	其它	1981	1985	
Northeast Forestry University	其它	1978	1979	
Sandao Communes in Yanji County, Jilin Province	其它	1969	1975	

Note: ★ denotes military service or related organizations.

ATTACHMENT A-2

Corporation Profile (Partial) of Aviation Industry Corporation of China

Relational Network of State Administration for Science, Technology, and Industry for National Defense Director Xu Dazhe

Future China-Minerva Database

—Where we learn about China.

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中国航空工业集团公司(Aviation Industry Corporation of China)

Established: 2008

Sector: Aerospace & defence

English Summary: AVIC Industry Corporation of China (AVIC) is one of the China's top ten military industrial enterprises. It was founded on November 6 of 2008 through the restructuring and consolidation of China Aviation Industry Corp I (AVIC I) and China Aviation Industry Corp II (AVIC II). AVIC is a corporation, centered on aviation, but capable of providing whole-value chain services to customers in many fields, from research and development to operation, and from manufacturing to finance. Its business units cover defense, transport aircraft, engines, helicopters, avionics and systems, general aviation, aviation research, flight test, trade and logistics, asset management, financial services, engineering planning and construction, and automobiles.

Chinese Summary: 中国航空工业集团公司（简称“中航工业”）是中国十大军工企业之一，是由中央管理的国有特大型企业，是国家授权投资的机构，于2008年11月6日由原中国航空工业第一、第二集团公司重组整合而成。集团公司设有航空装备、运输机、发动机、直升机、机载设备与系统、通用飞机、航空研究、飞行试验、贸易物流、资产管理、工程规划建设、汽车等产业板块。

Category

Region	Category	SZSS Stock Market Code	HK Stock Market Code	Listing Date	Discloser	Legal Representative	SZSS Security Type	HK Security Type	Est_Date	Source
Domestic	State-owned Holding Company - CENTRAL									百度百科 - 中国飞机强度研究所

Names

Type	Name	From	To
English Name	Aviation Industry Corporation of China	2008	Present
Abbreviation	AVIC	2008	Present
Chinese Name	中国航空工业集团公司	2008	Present
Abbreviation	中航工业	2008	Present

Location

Country	Province	City	Township	Village	District	Street Number	Zip Code	From	To
China	北京 Beijing	Beijing			Chaoyang	No.128 Jianguo Road	100022	2008	Present

ATTACHMENT A-3**Relational Network of State Administration for Science, Technology, and Industry for National Defense Director Xu Dazhe**